GROWTH-RATE OF THE PEARL OYSTER, *PINCTADA PINCTADA* IN THE GULF OF KUTCH WITH A NOTE ON THE PEARL FISHERY OF 1953[1]

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(*With five text figures*)

CONTENTS

INTRODUCTION

Pearl Oysters are commonly found off the Northern Coast of the Halar District (Saurashtra) in the Gulf of Kutch. The species has been recorded in the Directorate of Marine Products, Saurashtra as *Pinctada pinctada* and for the sake of convenience it has been referred to by the same name in this paper but this identification is not final yet. These oysters are found attached to coral reefs (known locally as 'kadda') of which 42 have been charted off the Halar Coast. Some of the important reefs are shown in the accompanying map. These reefs are situated in the inter-tidal zones and get completely exposed during the low tides. Collection of these oysters is, therefore, a comparatively simple operation and does not entail any diving, etc. Pearls have been obtained fairly regularly from these waters for the last two hundred years at least and are well-known for their lustre and brilliance. We are not aware of any systematic work that has been carried out on the bionomics of these oysters in the Gulf of Kutch. It was decided to undertake the study of its growth-rate and find

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[1] Communicated by Mr. K. R. Srivatsa, the Director of Marine Products, Government of Saurashtra.

The investigations described here were conducted under the Pearl Oyster Research Scheme of the Government of Saurashtra.

out the approximate age at which the pearl-formation starts, for which purpose a Pearl Oyster Research Scheme was sanctioned by the Government of Saurashtra. Such studies have both commercial as well as scientific importance which cannot be over-emphasized.

Previous Work

In his paper on *K. apima*, Rao (1951) has surveyed some of the work that has been carried out on the bivalve molluscs in the tropical seas. According to him, Herdman (1903) and Malpas (1933) have studied the growth-rate of the Ceylon Pearl Oyster, *Pinctada vulgaris*. Hornell (1922) and Cahn (1949) are other workers not mentioned by Rao. Hornell studied the growth-rate of the Ceylon Pearl Oyster while Cahn has traced the entire life-history of the Japanese Pearl Oyster, *Pinctada martensii*. None of these authors mention the use of annular growth-rings in their studies. Rao (1951) has himself used such rings for ascertaining the age of *K. apima* and has shown that his readings agree with the length-frequency measurements. According to him the rings are 'disturbance rings' caused by the cessation of growth which, in itself, may be due to a drop in the salinity of the sea-water. He finds sufficient regularity in the occurrence of these 'disturbance rings' to justify assumption that they indicate the approximate age of the animal. Growth-rings are known to occur annually in the skeletal structures of fishes and on the shells of bivalves such as *Pecten sp.*, etc. in the temperate seas. From our observations on the pearl oysters kept in cages at Sikka from 1951 we found that such rings are formed annually on their shells and hence we have used them in our studies.

Material and Methods

Other material for these investigations was collected mainly from the pearl fishery of 1953. It was not possible to examine each and every oyster fished during this period and we had to content ourselves with random samples taken from this stock. Under the existing regulations the fishermen employed for collection could not bring in oysters below a certain size-limit. Consequently the stock fished was itself bias towards the older animals and this was also reflected in the random samples obtained by us. We were unable to get specimens of age-groups '0' and '1'. Even the number of animals belonging to age-group 2 was very small making it difficult to calculate the average size of that group accurately. On the other hand, seven-year old animals, though not affected by this selection were a few in number while only three eight-year animals were obtained. The total number of oysters fished during the Pearl fishery of 1953 was 11,519 of which 1,353 constituted the random samples and were examined in detail. Apart from these, 334 oysters kept in cages in the Pearl Oyster Park at Sikka were measured regularly every month for a period of two years and formed the main source for observing the formation of 'growth-rings'.

In the beginning three different types of linear measurements were recorded—the length, the depth and the thickness. The lines of these

measurements are shown in Fig. 1. It was, however, soon apparent that the thickness gave more consistent data than the rest and hence in later studies only the thickness was measured. This incidentally made it possible to measure a large number of animals.

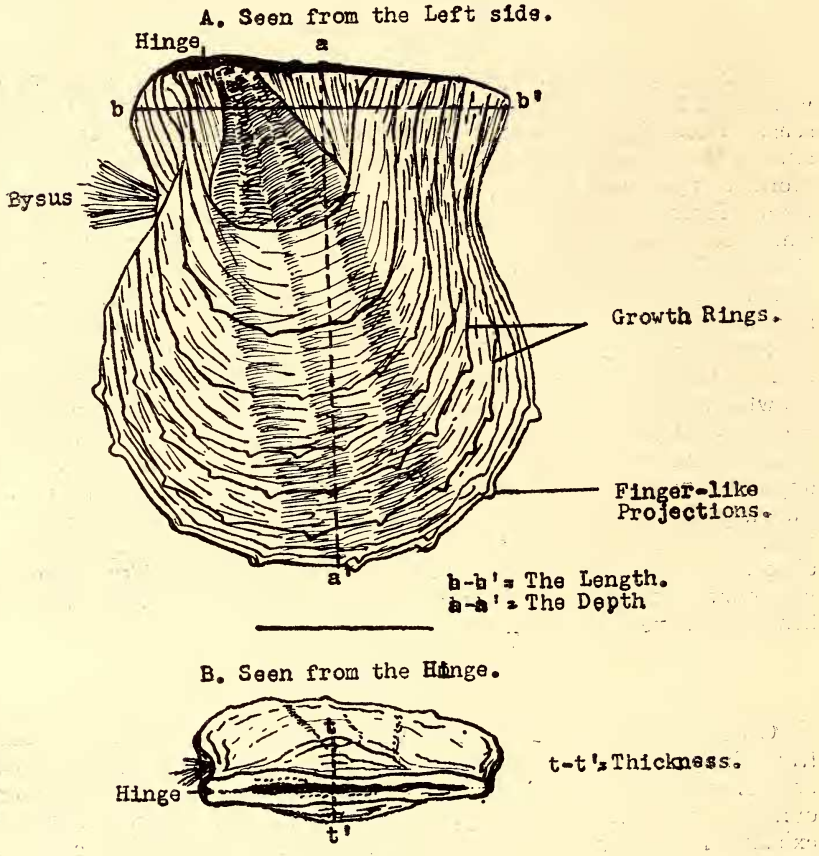


Fig. I

Diagrammatic Sketch of *P. pinctada*

Thickness can be defined as the maximum distance between the external surfaces of the two valves of the oyster. These measurements could easily be made with a pair of callipers and were recorded to the nearest millimeter. The number of 'rings' on the valves were also observed and recorded against the particular individual for correlation studies.

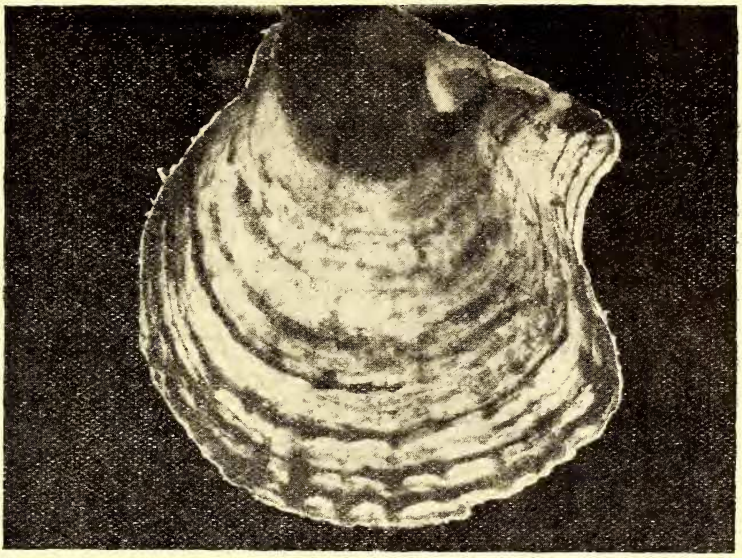
Age-Analysis

(a) Growth-rings:

Fig. II shows a photograph of the right valve of an oyster five years old. There are a number of concentric rings on the valve but out of them five are seen better marked than the rest. These are

referred to in the following pages as 'growth-rings' or merely as 'rings'. The formation of these rings appears to be as follows:—

Towards the free edge of a young oyster are always seen small finger-like projections. These are particularly better marked during winter when the growth is quite fast. During summer when the



[*Photo by Jamnagar Photo Co.*

FIG. II

Photograph of the right valve of a five-year old *P. pinctada* silhouetted against powerful artificial light. The black portion towards the straight margin is the point of maximum thickness. (Reduced to five-eighth of the original size.)

growth slows down these projections disappear and instead there appears a continuous line—the growth-ring. Later on fresh projections appear which will give rise to the next year's ring. A real ring is one which is continuous from the anterior to the posterior end and is much deeper than the rest. The rings are better seen on the deeper left valve than the right but it is safer to see carefully both the valves before coming to any conclusion. In case of doubt the valves may be separated and each seen silhouetted against the sunlight when the true rings appear very clear. Even so the differentiation of true rings from the 'false' rings is difficult and it is only after some experience that it becomes possible to identify the age correctly. About 5% of the oysters had to be discarded because no proper differentiation of the lines could be made.

(b) Period of ring-formation:

That these rings are annual features (formed once in a year) and represent a year's growth was proved by our observations on the oysters kept in cages at Sikka. It was found that in a majority of cases the rings were formed during the summer months when the growth ceased. It was also ascertained from these records that

these rings were permanent features and once formed never diminished in size.

To avoid any mistake occurring through the subconscious each oyster in our Park was given a serial number and its rings were counted every month without referring to the previous records. So far only four oysters have been found incorrectly read. This in itself is a proof that the method is quite valid and reliable in the age-analysis of these oysters.

(c) Probable Causes:

As regards the causative factors of the periodic growth of the oysters and the formation of the rings, nothing can be said with certainty. Cahn (1949) finds two distinct periods each year—one of faster growth and the other of comparative rest—in the Japanese oyster and attributes the slower rate chiefly to the drop in the sea-temperature during December to April when oysters hibernate. Fig. III shows the mean sea-temperatures (taken near the bottom) at the

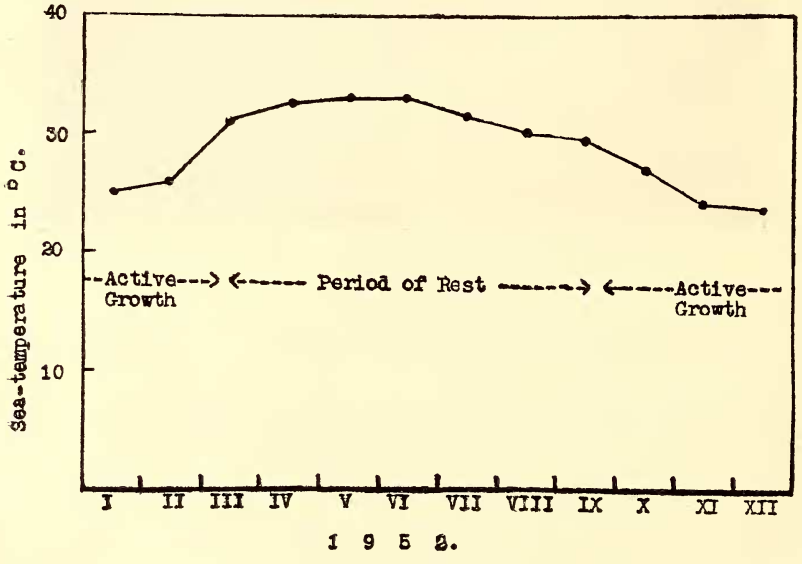


Fig. III

Mean Sea-temperatures from the Pearl Oyster Park at Sikka

Pearl Oyster Park at Sikka. Also shown on the graph are the periods of active growth and rest as observed at Sikka. It will be seen from this data that the oysters in the Gulf of Kutch grow vigorously between November and February when the temperature of the sea varies between 23°C. and 27°C. while during the summer months, when the temperature is higher, the growth ceases. However the difference between the summer and winter temperatures is not so high as to justify the assumption that this physical factor is mainly responsible for the cessation of the growth; especially so, when one considers that these temperatures represent only the means. In day-to-day temperatures there was too much of variation and even over-

lapping. Rao (1951) finds that growth in *K. apima* seems to be arrested during August to December when there is a fall in salinity of the sea-water. Salinity in the Gulf of Kutch does not show appreciable fluctuations and we have no evidence to presume that it has anything to do with the retardation of growth. Cessation of growth due to metabolic strains such as caused by low feeding or spawning is known to occur amongst some of the marine fishes particularly those of the temperate seas. Enough data on the biology of these oysters are not yet available and hence it would be too premature to comment on these factors but it is likely that they are more likely causes of the cessation of the growth amongst the oysters than the sea-temperature.

(d) Growth-rate:

In studies on age-analysis with the help of annual rings it is very essential to know the approximate age of the individual at the time when the first ring is laid down. Since we do not know the exact extent of the spawning season of *P. pinctada* nor do we have enough specimens of age-groups '0' and '1', we are not in a position to say when the first ring is laid down and consequently our readings are likely to be wrong by six months on either side. Thus when we say that the oyster is 4 years old, it may be anything between 3 years 6 months and 4 years 6 months.

As stated previously the thickness was correlated with the rings and the data thus obtained is shown in table 1. The average thickness (weighted means) of oysters at various ages calculated from this data are given below:—

Age	*Thickness in mm.*
2	21·8
3	25·0
4	29·2
5	32·7
6	35·4
7	37·2 (?)

The number of two-year old animals is very small in table 1 and hence their average may not be correct. Moreover, oysters lesser than 15 mm. thick were not collected. If these could have been included in this data, the average thickness of that age group would have gone down. Similarly, only 19 specimens of age group 7 were obtained and the average thickness may, therefore, not be reliable. This data shows that the oyster grows quite fast till its fourth year but after that age the growth-rate slows down. These findings are similar to those of Hornell (1922) who observes that 'the growth of the Indian oyster is distinctly retarded after the third year'. We, however, feel that this slowing down of the growth-rate is not so much due to the 'abundance of encrusting organisms' suggested by Hornell as due to a drop in the general metabolism with the advancing age. Marine fishes are known to grow fast till they attain sexual maturity after which their growth-rate falls. It is likely that the pearl oyster reaches sexual maturity towards its 3rd or 4th year which may explain the drop in the growth-rate after that age.

The life-span of *P. pinctada* in the Gulf of Kutch seems to be seven years though a few individuals survive to the eighth year. According to Hornell (1922) the pearl oyster in the Gulf of Manaar

TABLE 1

Correlation between the thickness and the age of *P. pinctada*.

Thickness in mm.	2 yrs.	3 yrs.	4 yrs.	5 yrs.	6 yrs.	7 yrs.	Total
18	1	—	—	—	—	—	1
19	4	—	—	—	—	—	4
20	13	4	—	—	—	—	17
21	14	9	1	—	—	—	24
22	12	14	—	—	—	—	26
23	11	28	4	2	—	—	45
24	8	52	6	4	—	—	70
25	4	66	18	5	1	—	94
26	1	53	33	2	1	—	90
27	—	30	50	5	1	—	86
28	—	13	58	4	1	—	76
29	—	10	97	13	2	—	122
30	—	2	124	42	5	—	173
31	—	1	42	56	2	—	101
32	—	—	31	67	3	—	101
33	—	—	10	35	7	2	54
34	—	—	8	62	7	2	79
35	—	—	13	57	18	2	90
36	—	—	2	14	21	3	40
37	—	—	2	6	8	2	18
38	—	—	1	7	3	2	13
39	—	—	—	2	2	1	5
40	—	—	—	—	7	1	8
41	—	—	—	—	5	2	7
42	—	—	—	—	3	2	5
43	—	—	—	—	2	—	2
44	—	—	—	—	2	—	2
Total ...	68	282	500	383	101	19	1 353

lives to about five years of age, while according to Cahn (1949) *P. martensii* lives to about eight years. Hornell has not given any basis of his age-assessment but Cahn has summarised the studies of Mr. M. Yanagonchi of the Japan Institute of Scientific Research on Pearls. Mr. Yanagonchi has traced the entire developmental history of *P. martensii* and hence his findings are more reliable than those of Hornell. Comparing Cahn's data with ours it seems that there is not much difference between the life-spans of *P. pinctada* and *P. martensii*.

(e) Agreement with Petersen's Method:

Petersen's method essentially consists in measuring a very large number of individuals of a species and finding out the 'peaks' or the 'modes' which represent various age-groups. This method gives good results particularly for the young growing animals when the growth-rate is quite fast and distinct modes are seen; but with the advanc-

ing age the growth-rate falls and very often Petersen's curve does not show any peak at all.

In fig. IV is shown a histogram of the thickness-frequencies of the pearl oyster. Superimposed on this are the lines indicating the average thicknesses of various age-groups as deduced from the rings. Except for the age-group 7 there is a fairly good agreement between the peaks of Petersen's method and the thickness claculated from the rings. The number of seven-year old animals was small which may be responsible for the disagreement. Moreover, as stated earlier the growth-rate at this age falls considerably and consequently Petersen's method cannot be solely relied upon; but the agreement which exists amongst other age-groups is ample proof of the reliability of the method of age-analysis with the help of annular rings.

Population Study (Analysis of the Stock)

A total of 11,519 oysters were fished during the Pearl Fishery 1953. During the pearl fishery of 1950 we had obtained 33,720 oysters and on an average about 17,000 oysters have been fished in each of the previous fisheries since 1913. The drop in the output this year is primarily due to shortage of fishermen who volunteered for the fishery. *Per capita* production, however, has remained the same.

When random samples were studied from this stock, some interesting information was obtained and which is summarized below:—

(i) The stock is a normal population. The various year-broods were represented as follows:—

1951 brood	...	...	5%
1950 brood	...	...	21%
1949 brood	...	...	37%
1948 brood	...	...	28%
1947 brood	...	...	8%
1946 brood	...	...	1%

These figures are represented in histogram in figure V. The population does not show any signs of over-fishing. The fact that 1950 brood forms about one-fifth of the stock and that the 1949 and 1948 broods form the bulk of the population today, prove that fishing conducted during 1950 was restricted to the older animals only and that too perhaps after spawning. A proper survey of animals belonging to 1951 brood will give a definite answer to this problem, but that two of us (C.R.E. and R.N.) collected twenty-five such animals within a search of two hours lends supports to this belief.

(ii) Growth-rate of the oysters was not the same on all the beds. Amongst the oysters collected from Movada and Deda, a majority were older oysters and even the rate was faster. Movada also provided the youngsters mentioned above. It is likely that these beds have probably the optimum conditions for the growth and propagation of the pearl oysters.

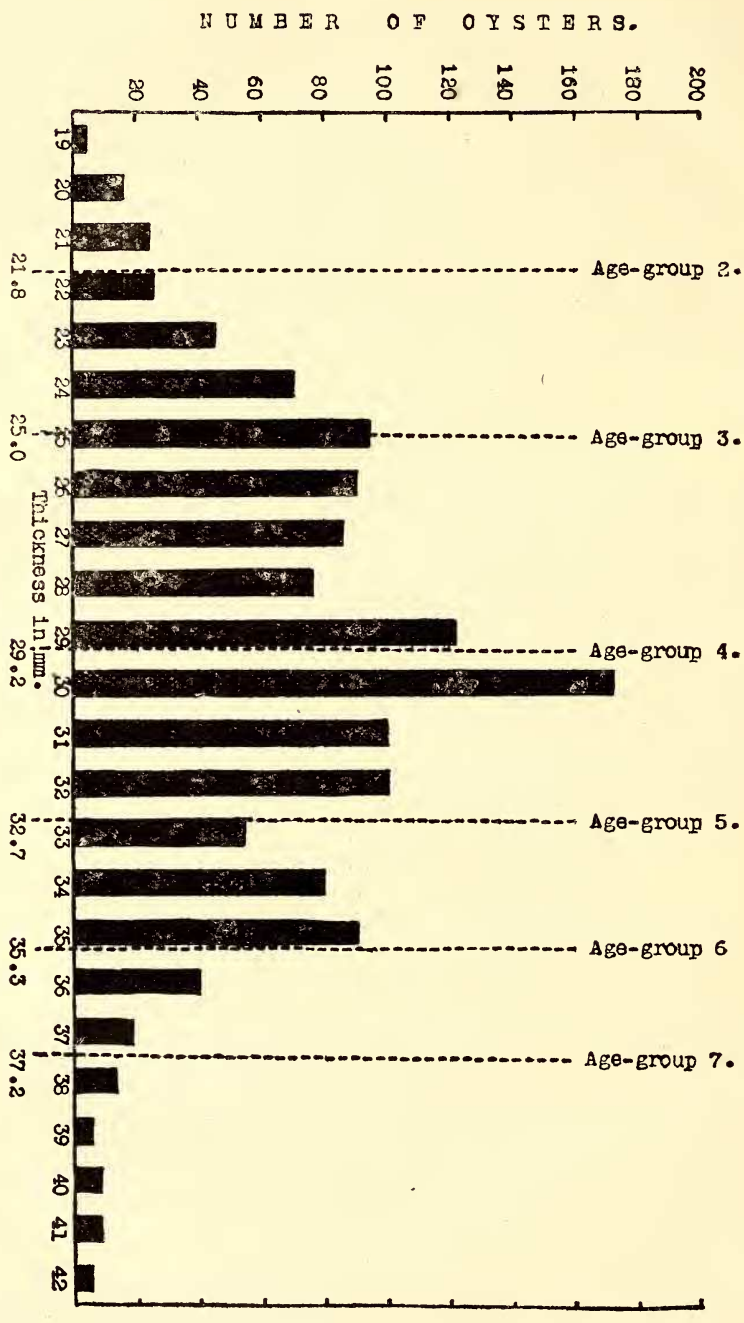


Fig. IV

Histogram showing the frequency of thickness

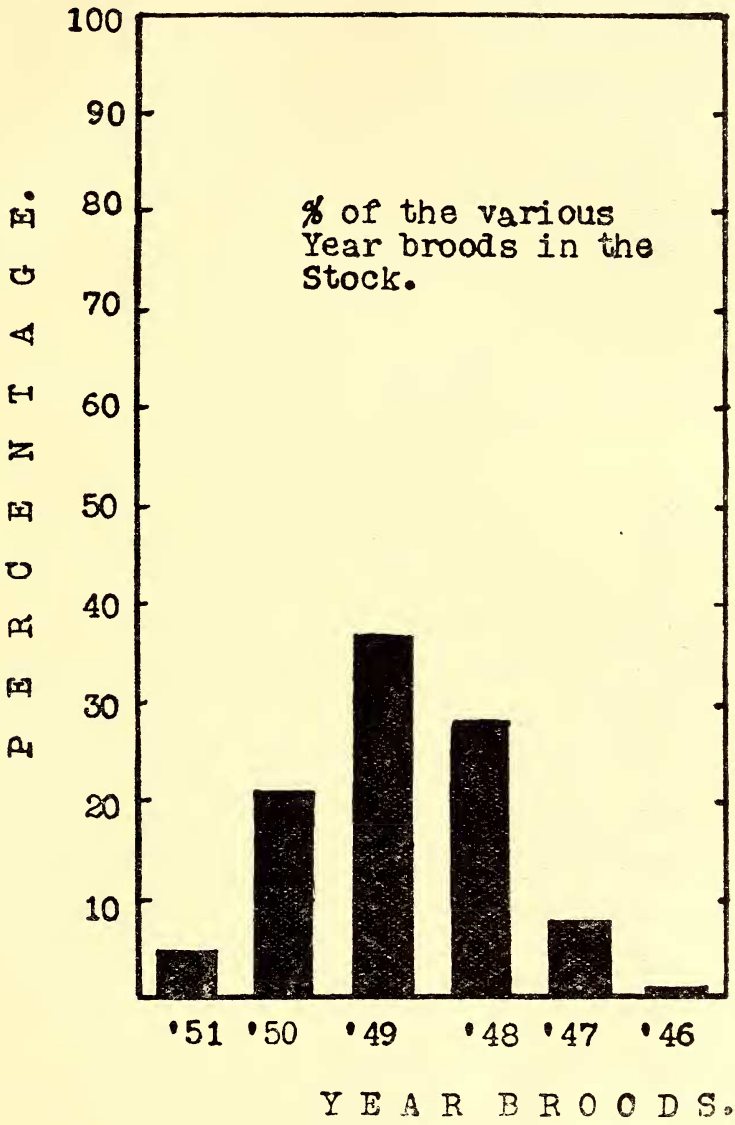


Fig. V

(iii) When the growth-rate of these 'wild' oysters (i.e. collected during the pearl fishery) was compared with that of oysters kept in cages at the Sikka Park, it was found that the latter showed a distinct retardation of growth after the third year. Since the number measured in the Sikka Park is rather small (334) we do not commit ourselves on this point but there is an indication that the growth in the Park is not very satisfactory. At present we are keeping the oysters in cages with wire meshes on one side and wood on the other three. Obviously these are not suitable for healthy growth.

Perhaps bamboo-fence enclosing a few acres of the oyster bed will serve the purpose better, although this will be more expensive.

(iv) On an average 15 to 20% oysters bear pearls. Narada bed differed in this respect in that about 30% oysters had pearls in them. Even the quality of the pearls produced in this bed was decidedly better. This is borne out by the fact that the total number of oysters collected from this bed in the sample survey was only 741 while the value of pearls was Rs. 2,380, a much higher average than that usually obtained.

(v) When the pearl bearing oysters were classified into their respective age-groups, the following data was obtained:—

Age-group	Number of oysters	Percentage
2	3	—
3	35	16·9%
4	68	32·8%
5	76	36·7%
6	25	23·6%
7	4	—

It appears from this data that the optimum conditions for the formation of pearls exist in the oyster when it is between three and six years old. Pearl formation starts at the age of three and rarely at two. It has already been shown that six-year old animals form only 8% of the stock. Looking from this point of view it seems that chances of pearl formation are more in 6-year old animals than in other age-groups. Cahn (1949) points out that three-year old animals are chosen for inserting the nucleus in the oyster for cultured pearls in Japan and that the harvesting age is between 6 and 7. Our data also points in the same direction and culture experiments, if and when started, should be attempted when the oysters are three years old.

A point worth considering in this respect is whether the present system of conducting pearl fisheries every third year is scientifically correct. From the above data it would appear that conducting a fishery every fourth or even fifth year should be more beneficial than in the third. There is, of course, the danger of losing the older oysters altogether but if fishing is done intensively and the old oysters removed this difficulty can be overcome. Moreover, the number of 6- and 7-year old animals is small and they can be removed by the departmental staff during their inspection tours.

(vi) Majority of the pearls were found near about the adductor muscle, mostly towards the hinge. We could not give proper attention to the study of location of pearls, etc., but mostly they were muscle pearls and smaller cyst pearls as defined by Hornell (1922).

Usually the muscle pearls appeared in clusters. Most of the pearl-bearing oysters contained more than three or four pearls each. It was exceptional to find only one pearl in an oyster. The highest number of pearls so far recorded from a single oyster is 68. Fusion of two or more pearls to form a bunch was not uncommon. It may be mentioned here that pearls of high values have been obtained from these waters. During the pearl fishery of 1950 one pearl was valued at Rs. 1,000 while the records show that during 1943-44 one pearl valued at Rs. 12,000 was collected from an oyster from the Narada Bed.

Summary

(i) The growth-rate of the adult pearl oyster, *Pinctada pinctada* in the Gulf of Kutch has been worked out with the help of annual rings. As the samples were bias, the growth-rate of two-year old and younger animals could not be calculated.

(ii) Two distinct periods—one of active growth and the other of rest—were observed in a year but no cause could be traced. It is likely that some internal biological factor is responsible for this cessation of growth.

(iii) It has been shown that the oysters grow fast till they attain their fourth year after which the growth rate falls. It has been presumed from this that the animal reaches sexual maturity at the age of three or four.

(iv) Life-span of these oysters seems to be seven years, though a few survive to the eighth.

(v) From sample-surveys of the pearl fishery in 1953 it has been ascertained that there are no signs of overfishing. On the contrary there is every reason to believe that this year the beds have been much underexploited due to labour shortage.

(vi) On an average 15 to 20% oysters bear pearls. Amongst the pearl-bearing oysters, age-groups of 4, 5, and 6 years predominate. It is likely that the pearl formation starts when the oyster is 2-3 years old. It has been suggested that conducting the fishery every fourth year would be more beneficial.

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References

1. Cahn, A. R. (1949): Pearl Culture in Japan. *U.S. Department of Interior, Fish and Wild Life Service Fishery Leaflet* 357, November, 1949.

2*. Herdman, W. A. (1903): Observations and Experiments on the Life-History and Habits of the Pearl Oyster. Rep. Pearl Oyster Fisheries of the Gulf of Manaar. *Royal Soc., London.* **1**: 125-146.

3. Hornell, J. (1922): The Indian Pearl Fishery of the Gulf of Manaar and Palk Bay. *Madras Fisheries Department Bulletin*, No. 16.

4*. Malpas, A. H. (1933): Further Observations on the Age and Growth-Rate of the Ceylon Pearl Oyster, *Margaritifera vulgaris*, with Special Reference in Oysters of Dorman's Muthuvarathu Paar. *Ceylon Journ. Sci.*, **5** (*c*): 21-48.

5. Rao, K. V. (1951): Studies on the growth of *Katelysia opima* (Gmelin). Section II of *Proceedings of the Indo-Pacific Fisheries Council.* 1951.

6. Devanesan, D. W. & Chidambaram, K. (1950): Report on Pearl Oyster of the Gulf of Manaar. (unpublished).

Addendum

During discussion on the growth-rate of Pearl Oysters with Shri K. Chidambaram, Assistant Fisheries Development, Advisor to the Government of India in February 1954 he referred to the attempts of the Madras Fisheries Department to study bionomics of the pearl oyster of the Gulf of Mannar. An unpublished report on these studies extending over a period of nine years by D. W. Devanesan and K. Chidambaram (1950) was made available to us. These workers reared spats of known age and correlated age of oysters with body or thickness at the hinge as factors in age and growth assessment. The extensive investigations carried on by them for prolonged period, if reported and published would be valuable to workers on Bionomics of Molluscs.

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* Papers are not seen by us.